DRAFT

A Guide to the Preparation of Bering Sea and Aleutian Islands Crab SAFE Report Chapters

A chapter should be produced for the SAFE report in all cases, and should include all sections listed in the "Outline of SAFE Report Chapters" below. This Outline is intended to provide a consistent structure and logical flow for stock assessments; using the numbering system outlined below will help to standardize the SAFE document and make the review process for assessments more straightforward. Some variation from this outline is permissible if warranted by limitations of data or other extenuating circumstances; major deviations from the suggested report structure should, however, be justified. Many of the items under Section E are not appropriate for stocks in Tier 5 (see Table 1 for a list of sections needs for different types of assessments). It is particularly important that all of the items listed under "Calculation of the OFL" be included to the maximum extent possible, in that many of these are critical to the fishery management process. Careful consideration should be given to all applicable SSC and CPT comments from the previous assessment(s). Fishing mortality values (F) are always full selection fishing mortality (the F at fishing selectivity equal to 1.0).

Important notes:
- This guide does not provide details on what is needed regarding ABCs and ACLs and will need to be modified once these details become available.
- Dates should be specified as "2008" for the 2008 calendar year and "2008/09" for the 2008/09 fishing year. By default crab assessments are based on fishing years, but the notation 2xxx/yy should nevertheless be adopted.

Outline of SAFE Report Chapters

Title page and list of preparers

Executive Summary
1. Stock: species/area.
2. Catches: trends and current levels.
3. Stock biomass: trends and current levels relative to virgin or historic levels, description of uncertainty.
4. Recruitment: trends and current levels relative to virgin or historic levels.
5. Management performance: a table showing estimates of mature male biomass (at the time of mating), overfishing levels (OFL and MSST), TACs, retained catch and discards in all fisheries; show results from 2005/06 to the current year (Table 2 lists examples of how these tables should be constructed for stocks in each Tier)
6. Basis for the OFL: Table listing estimates of M, Tier level, current mature male biomass (at the time of mating), B_{MSY} (or the proxy thereof) and the basis for the calculation of B_{MSY}, current mature male biomass relative to B_{MSY} (or its proxy), γ, and the basis for calculating average catch; show from 2008/09 to the current year (Table 3 lists examples of how these tables should be constructed for stocks in each Tier).
7. A summary of the results of any rebuilding analyses: table showing the year by which rebuilding is expected to occur, the maximum time allowed for recovery, the catch for the next fishing year

and probability of recovery to the proxy for B_{MSY} for a range of harvest strategies (including one for which the probability of recovery is 0.5).

A. Summary of Major Changes

1. Changes (if any) to the management of the fishery.
2. Changes (if any) to the input data.
3. Changes (if any) to the assessment methodology.
4. Changes (if any) to the assessment results, including projected biomass, TAC/GHL, total catch (including discard mortality in all fisheries and retained catch), and OFL.

B. Responses to SSC and CPT Comments

1. Responses to the most recent two sets of SSC and CPT[1] comments specific to this assessment (for each comment that is addressed in the main text, list the comment and give the name of section where it is discussed; if the SSC or CPT did not make any comments specific to this assessment, say so).
2. Responses to the most recent two sets of SSC and CPT[1] comments on assessments in general (for each comment that is addressed in the main text, list the comment and give name of the section where it is discussed; if the SSC or CPT did not make any comments on assessments in general, say so).

All comments relevant to this assessment and crab assessments in general must be listed. If a comment has not been addressed in the assessment, the comment should be listed and the reasons for not addressing it must be provided.

C. Introduction

1. Scientific name.
2. Description of general distribution (including a map).
3. Evidence of stock structure, if any.
4. Description of life history characteristics relevant to stock assessments (e.g., special features of reproductive biology)
5. Brief summary of management history. A complete summary of the management history will be provided and ADG&F AMR Fishery Report.

D. Data (Items in this section should be presented primarily in tabular form.)

1. Summary of new information.
2. Data which should be presented as time series, separately by sex and, depending on the assessment also by maturity state and shell condition (table headers should indicate when the data were extracted, and the source for the data; years should be reported as fishing year 2xxx/yy or calendar year, depending on the fishery concerned):
   a. Total catch, partitioned by strata used in the assessment model, if any.
   b. Information on bycatch and discards. Non-retained catches and discards should ideally be reported using the categories in Table x (the table header should specify the mortality rates

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[1] For an assessment in May, these comments will be from the SSC and CPT meetings in May and September of the previous year. For an assessment in September, these comments will be from the SSC and CPT meetings in May of the current year and September of the previous year.

applied to discards and bycatch, and whether the values in the table have had these mortality rates applied or not).
   c. Catch-at-length (with sample sizes) for fisheries, bycatch, and discards.
   d. Survey biomass estimates (with measures of uncertainty).
   e. Survey numbers-at-length (with sample sizes), as appropriate.
   f. Other time series data (e.g., predator abundance, fishing effort).
3. Data which may be aggregated over time:
   a. Length-at-age (by sex).
   b. Growth-per-molt; frequency of moulting, etc. (by sex and perhaps maturity state)
   c. Weight-at length or weight-at-age (by sex).
4. Information on any data sources that were available, but were excluded from the assessment.

Notes:
   i. Information on length-composition may be more appropriately presented in the form of plots, especially for assessment for which there in a substantial amount of such data.
   ii. The reported samples sizes should reflect the actual number of samples; information on the sample sizes assumed when fitting any population models should also be reported.

E. Analytic Approach

1. History of modeling approaches for this stock

In addition to summarizing how assessments methods have changed over time, include a summary of CIE review comments from past reviews and how those comments have been taken into account.

2. Model Description

   a. Description of overall modeling approach (e.g., age/size structured versus biomass dynamic, maximum likelihood versus Bayesian). If the model has not been published in its current form, its equations should be listed in full in an Appendix. It there is a technical Appendix, Items b-f below should be included in the appendix, and only a short description of the model and its estimation scheme needs to be included in this section. Specify when the fishery is assumed to occur and, if necessary, provide a table which lists the assumed time of the fishery for each year of the assessment period.
   b. Reference for software used (e.g., Synthesis, AD Model Builder).
   c. List and description of all likelihood components.
   d. Description of how the state of the population at the start of the first year of the assessment period is determined and the size-range that the model covers.
   e. Parameter estimation framework:
      i.   List all of the parameters which are estimated outside of the assessment (e.g., the natural mortality rate, parameters governing the maturity schedule) along with how the values for these parameters were estimated (methods do not necessarily have to be statistical; e.g., M could be estimated by referencing a previously published value).
      ii. List all of the parameters that are estimated conditionally on those described above (e.g., full-selection fishing mortality rates, parameters governing the survey and fishery selectivity schedules, recruitments), indicate any bounds and/or priors placed on these parameters.
      iii. List any constraints that imposed on the estimated parameters (including penalties on recruitment and selectivity).

f. Definition of model outputs

    i. Biomass measures (e.g., biomass of animals 50mm and larger). Indicate the assumed time of mating and that of the fishery.

    ii. Recruitment (e.g., number of males and females in the 50-55mm size-class).

    iii. Fishing mortality (e.g., full-recruitment F multiplied by selectivity for lengths 80 and above). Whether fishing mortality is an exploitation rate or an instantaneous rate should be reported in table headers and the text. The ideal is to report "fishing mortality" as the fully-selected instantaneous fishing mortality rate at the time of the fishery to enhance comparability amongst stock assessments.

g. Critical assumptions and consequences of assumption failures (for example, highlight assumptions regarding M, Q and selectivity, to which assessments are often very sensitive).

h. Changes to any of the above since the previous assessment.

i. Outline of methods used to validate the code used to implement the model and whether the code is available.

3. Model Selection and Evaluation

a. Description of alternative model configurations, if any (e.g., alternative M values or likelihood weights; use a hierarchical approach where possible (e.g. asymptotic vs domed selectivities, constant vs time-varying selectivities)). The model configuration on which the previous assessment was based must be included in the set of model considered in order to retain comparability with previous assessments.

b. Show a progression of results from the previous assessment to the preferred base model by adding each new data source and each model modification in turn to enable the impacts of these changes to be assessed.

c. Evidence of search for balance between realistic (but possibly over-parameterized) and simpler (but not realistic) models.

d. Convergence status and convergence criteria for the base-case model (or proposed base-case model) such as randomization run results or other evidence of a search for the global best estimates.

e. Table (or plot) of the sample sizes assumed for the compositional data. There are several ways for specify input sample size, including:

    i. the number of animals actually measured;

    ii. a fixed constant (e.g. 500);

    iii. the application of bootstrapping approaches (e.g. Folmer and Pennington, 2000); and

    iv. as for i and iv, with a maximum imposed on the input sample size

The first, third, and last of these approaches allows the input sample sizes (and hence the weight assigned to the compositional data) to reflect uneven sampling over time. The basis for specifying the input sample sizes should be justified and analyses conducted (see Section 4.4 below) to justify the final effective sample sizes.

f. Do parameter estimates for all models make sense, are they credible?

g. Description of criteria used to evaluate the model or to choose among alternative models, including the role (if any) of uncertainty.

h. Residual analysis (e.g. residual plots, time series plots of observed and predicted values or other approach). Note that residual analysis is expected for the base-case model below.

i. Evaluation of the model, if only one model is presented; or evaluation of alternative models and selection of final model, if more than one model is presented.

4. Results (best models)

Results should be provided for all model runs that the assessment author considers sufficiently plausible that they could form the basis for management advice. Assessment authors should come to the May CrabPLAN meeting with detailed results for all analyses conducted.

1. List of effective sample sizes, the weighting factors applied when fitting the indices, and the weighting factors applied to any penalties.
2. Tables of estimates (all quantities should be accompanied by confidence intervals or other statistical measures of uncertainty, unless infeasible; include estimates from previous SAFEs for retrospective comparisons):
   a. All parameters (include recruitments, selectivity parameters, any estimated growth parameters, catchability, etc.).
   b. Abundance and biomass time series, including spawning biomass and mature male biomass (MMB).
   c. Recruitment time series (including average recruitment).
   d. Catch/biomass time series.
3. Graphs of estimates (all quantities should be accompanied by confidence intervals or other statistical measures of uncertainty, unless infeasible):
   a. Fishery and survey selectivities, molting probabilities, and other schedules depending on parameter estimates.
   b. Estimated male, female, mature male, total and effective mature biomass time series (indicate the proxy for B_{MSY} on the plot).
   c. Estimated full selection F over time.
   d. Estimated fishing mortality versus estimated spawning stock biomass, including applicable OFL and maximum F_{target} definitions for the stock (see, for example, Fig. 54 of Turnock and Rugolo, 2008). Graphs of this type are useful to evaluate management performance.
   e. Fit of a stock-recruitment relationship.
4. Evaluation of the fit to the data:
   a. Graphs of the fits to observed and model-predicted catches (retained catch and discards), including model-predicted of catches and discards for all years to allow discards to be inferred for years for which data are not available.
   b. Graphs of model fits to catch numbers (include confidence intervals for the data and model predictions).
   c. Graphs of model fits to survey numbers (include confidence intervals for the data and model predictions).
   d. Graphs of model fits to catch proportions by age or length (e.g. using bubble and/or line plots).
   e. Graphs of model fits to survey proportions by age or length (e.g. using bubble and/or line plots).
   f. Marginal distributions for the fits to the compositional data.
   g. Plots of implied versus input effective sample sizes and time-series of implied effective sample sizes.
   h. Tables of the RMSEs for the indices (and a comparison with the assumed values for the coefficients of variation assumed for the indices).
   i. Quantile-quantile (q-q) plots and histograms of standardized residuals (to the indices and compositional data) to justify the choices of sampling distributions for the data and include any data "weights" in these calculations.
5. Retrospective and historic analyses

a. Retrospective analysis (retrospective bias in base model or models).
b. Historic analysis (plot of actual estimates from current and previous assessments).
6. Uncertainty and sensitivity analyses (this section should highlight unresolved problems and major uncertainties, along with any special issues that complicate scientific assessment, including questions about the best model, etc.):
    a. The best approach for describing uncertainty depends on the situation. Possible approaches (not mutually exclusive) are:
        i. Sensitivity analyses (tables or figures) that show ending biomass levels, OFLs, and/or likelihood component values obtained while systematically varying (e.g. halving and doubling) the emphasis factors for each type of data (and penalty) in the model.
        ii. Likelihood profiles for parameters or biomass levels.
        iii. CVs for biomass or OFL estimated by bootstrap, the delta method or Bayesian methods.
        iv. Subjective appraisal of the magnitude and sources of uncertainty.
        v. Retrospective and historic analyses (see above).
        vi. Comparison of alternate models and or assumptions (i.e. model structure uncertainty as evaluated in Section E.3).
    b. It is important that some qualitative or quantitative information about relative probability be stated if a range of model runs (e.g., based on CV's or alternative assumptions about model structure or recruitment) is used to depict uncertainty. It is important to state that all scenarios (or all scenarios between the bounds depicted by the runs) are equally likely if no statements about relative probability can be made.
    c. Simulation results.

F. Calculation of the OFL

1. Specification of the Tier level for computing the OFL, along with the basis for the selection. For Tier 4 and 5 stocks, the rationale for the time period used to define B_{REF} (Tier 4) and the average retained catch used to compute the OFL needs to be specified.
2. List of parameter and stock size estimates (or best available proxies thereof) required by limit and target control rules specified in the fishery management plan.
3. Specification of the OFL:
    a. Provide the equations (from the Amendment) on which the OFL is to be based, including the equations used to project discard and bycatch by sex (the mathematical specifications for this need to be documented in a peer-reviewed publication or in a technical appendix).
    b. Basis for projecting MMB to the time of mating (the mathematical specifications for this need to be documented in a peer-reviewed publication or in a technical appendix).
    c. Specification of F_{OFL}, OFL, and other applicable measures (if any) relevant to determining whether the stock is overfished or if overfishing is occurring (such as B_{REF}, $B_{35\%}$). Include estimates from the present assessment and the assessments since 2006/07. Table 2 lists examples of tables for Tiers 3, 4 and 5.
4. Recommendation for F_{OFL}, OFL total catch (or OFL retained catch) for coming year. List the OFLs by sector (retained catch, discard in the directed fishery, bycatch in other crab fisheries, the groundfish fishery, etc.), where appropriate.

G. Rebuilding Analyses

Rebuilding analyses should be provided for stocks which are overfished or which are currently under a rebuilding plan.

1. Definition of recovery (including the definition of the proxy for B_{MSY}, the number of years that the biomass needs to exceed the proxy for B_{MSY} for the stock to be recovered)
2. Year in which the rebuilding plan started and the year by which the stock should be recovered to the proxy for B_{MSY}.
3. Specification of the approach used to project the model forward (e.g. assumptions about parameter uncertainty; future recruitment and selectivity; and how discards and bycatch are computed given fishing mortality of mature males).
4. Projections under different levels of fishing mortality on mature males to evaluate the probability of recovery to the proxy for B_{MSY} over time. Results should be produced for (a) no targeted fishing, (b) probabilities of recovery of 0.5, 0.6, 0.7 and 0.8, and (c) a harvest strategy corresponding to 75% of the F_{OFL}.
5. Tables of total catch, retained catch, and probability of recovery against time for the rebuilding strategies listed under 4).

H. Data Gaps and Research Priorities

I. Ecosystem Considerations

Discussion of any ecosystem considerations (e.g., relationships with species listed under the ESA, prohibited species concerns, bycatch issues, refuge areas, and gear considerations).

The following subsections should provide information on how various ecosystem factors might be influencing the stock or how the fishery might be affecting the ecosystem and what data gaps might exist that prevent assessing such effects.

Stock assessment authors would be encouraged to rely on information in the Ecosystem Considerations chapter to assist them in developing stock-specific analysis and recommending new information to the Ecosystem Considerations chapter that might be required in future years to improve the analysis. Time-series that are in the Ecosystem Chapter should be referred to by the author and not duplicated in their chapter. In cases where the authors have time series or relationships that are specific to their stock, that information should be in their assessment chapter and not in the Ecosystem chapter.

1. Ecosystem Effects on Stock
There are several factors that should be considered for each stock in this subsection. These include:
- Prey availability/abundance trends (historically and in the present and foreseeable future). These prey trends could affect growth or survival of a target stock.
- Predator population trends (historically and in the present and foreseeable future). These trends could affect stock mortality rates over time.
- Changes in habitat quality (historically and in the present and foreseeable future). These would primarily be changes in the physical environment su ch as temperature, currents, or ice distribution that could affect stock migration and distribution patterns, recruitment success, or direct effects of temperature on growth.

2. Fishery Effects on the Ecosystem
In this section the following factors should be considered:

1. Fishery-specific contribution to bycatch of prohibited species, forage (including herring and juvenile pollock), HAPC biota (in particular, species common to *YourFishery*), marine mammals

and birds, and other sensitive non-target species (including top predators such as sharks, expressed as a percentage of the total bycatch of that category of bycatch).

2. Fishery-specific concentration of target catch in space and time relative to predator needs in space and time (if known) and relative to spawning components.
3. Fishery-specific effects on amount of large size target fish.
4. Fishery-specific contribution to discards and offal production.
5. Fishery-specific effects on age-at-maturity and fecundity of the target species.
6. Fishery-specific effects on EFH non-living substrate (using gear specific fishing effort as a proxy for amount of possible substrate disturbance).

Authors should consider summarizing the results of these analyses into a table as shown below (for example):

Analysis of ecosystem considerations for *YourStock* and the *YourFishery*. The observation column should summarize the past, present, and foreseeable future trends. The interpretation column should provide details on how the trend affects the stock (ecosystem effects on the stock) or how the fishery trend affects the ecosystem (fishery effects on the ecosystem). The evaluation column should indicate whether the trend is of: *no concern, probably no concern, possible concern, definite concern,* or *unknown.*

Ecosystem effects on *YourStock*

Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Stomach contents, ichthyoplankton surveys, changes mean wt-at-age	Stable, data limited	Unknown
Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	Possibly lower mortality on pollock	No concern
Birds	Stable, some increasing some decreasing	Affects young-of-year mortality	Probably no concern
Fish (Pollock, Pacific cod, halibut)	Stable to increasing	Possible increases to pollock mortality	
Changes in habitat quality			
Temperature regime	Cold years pollock distribution towards NW on average	Likely to affect surveyed stock	No concern (dealt with in model)
Winter-spring environmental conditions	Affects pre-recruit survival	Probably a number of factors	Causes natural variability
Production	Fairly stable nutrient flow from upwelled BS Basin	Inter-annual variability low	No concern

***YourFishery* effects on ecosystem**

Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Prohibited species	Stable, heavily monitored	Minor contribution to mortality	No concern
Forage (including herring, Atka mackerel, cod, and pollock)	Stable, heavily monitored	Bycatch levels small relative to forage biomass	No concern
HAPC biota	Low bycatch levels of (spp)	Bycatch levels small relative to HAPC biota	No concern
Marine mammals and birds	Very minor direct-take	Safe	No concern
Sensitive non-target species	Likely minor impact	Data limited, likely to be safe	No concern
Fishery concentration in space and time	Generally more diffuse	Mixed potential impact (fur seals vs Steller sea lions)	Possible concern
Fishery effects on amount of large size target fish	Depends on highly variable year-class strength	Natural fluctuation	Probably no concern
Fishery contribution to discards and offal production	Decreasing	Improving, but data limited	Possible concern
Fishery effects on age-at-maturity and fecundity	New study initiated in 2002	NA	Possible concern

J. Literature Cited

Include citations that are relevant to understanding the stock and its status, but are not cited in the report in a special "extra references" section.

References
Folmer O. and M. Pennington. 2000. A statistical evaluation of the design and precision of the shrimp trawl survey off West Greenland. *Fisheries Research* 49:165–178.
Turnock, B.J. and L.J. Rugolo. 2008. Stock assessment of eastern Bering Sea snow crab.

Table 1. Requirements for assessments by Tier.

Report Section	Tiers 1-3; Tier 4 (with assessment)	Tier 4 (no assessment)	Tier 5
Executive Summary	Yes	Yes	Yes
A. Summary of Major Changes	Yes	Yes	Yes
B. Responses to SSC and CPT comments	Yes	Yes	Yes
C. Introduction	Yes	Yes	Yes
D. Data	Yes	Yes[1]	Yes[2]
E. Analytical Approach	Yes	Yes[3]	Yes[3]
F. Calculation of the OFL	Yes	Yes	Yes
G. Rebuilding Analyses	Yes[4]	Yes[4]	Yes[4]
H. Data Gaps and Research Priorities	Yes	Yes	Yes
I. Ecosystem Considerations	Yes	Yes	Yes
J. Literature Cited	Yes	Yes	Yes

1 – Items 2c, 2e need not be reported in full
2 – Items 2c -2e need not be reported in full
3 – Limited to plots of survey data and catches
4 – Only for stocks under rebuilding

Table 2. Examples of summary tables of management performance by Tier level (the table is structured for an assessment conducted in September 2009)

(a) Stocks in Tiers 1-3 and those in Tier 4 for which there is an agreed assessment model

Year	OFL	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch
2005/06			100^A	60	40	58
2006/07			120^B	60	51	55
2007/08		230^C	130^C	60	55	56
2008/09	91	221^D	219^D	60	47	55
2009/10	78		280^D			

The stock was above MSST in 2008/09 and is hence not overfished. Overfishing did not occur during the 2008/09 fishing year.

Notes:
A – Calculated from the assessment reviewed by the CrabPLAN in September 2006
B – Calculated from the assessment reviewed by the CrabPLAN in September 2007
C – Calculated from the assessment reviewed by the CrabPLAN in September 2008
D – Calculated from the assessment reviewed by the CrabPLAN in September 2009

(b) Stocks in Tier 4 for which there is not an agreed assessment model

Year	OFL	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch
2005/06			100^A	60	40	58
2006/07			120^B	60	51	55
2007/08		230^C	130^C	60	55	56
2008/09	91	221^D	219^D	60	47	55
2009/10	78		280^D			

The stock was above MSST in 2008/09 and is hence not overfished. Overfishing did not occur during the 2008/09 fishing year.

Notes:
A – Based on survey data available to the CrabPLAN in September 2006 (even though it may have been updated)
B – Based on survey data available to the CrabPLAN in September 2007 (even though it may have been updated)
C – Based on survey data available to the CrabPLAN in September 2008 (even though it may have been updated)
D – Based on survey data available to the CrabPLAN in September 2009

(c) Stocks in Tier 5

Year	OFL	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch
2005/06			N/A	60	40	58
2006/07			N/A	60	51	55
2007/08		N/A	N/A	60	55	56
2008/09	91	N/A	N/A	60	47	55
2009/10	78		N/A			

No overfished determination is possible for this stock given the lack of biomass information. Overfishing did not occur during the 2008/09 fishing year.

Table 3. Examples of tables that summarize how the OFL was calculated (the table is structured for an assessment conducted in September 2009). The rows for 2008/09 were agreed by the CrabPLAN in September 2008 and those for 2009/10 were agreed by the CrabPLAN in September 2010.

(a) Stocks in Tiers 1-3 and those in Tier 4 for which there is an agreed assessment model

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Year to define B_{MSY}	Natural Mortality
2008/09	3b	231	219.5	0.95	$0.15yr^{-1}$	1978/79-2008/09	$0.25yr^{-1}$
2009/10	3a	234	245.7	1.05	$0.19yr^{-1}$	1978/79-2009/10	$0.25yr^{-1}$

(b) Stocks in Tier 4 for which there is not an agreed assessment model

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	γ	Year to define B_{MSY}	Natural Mortality
2008/09	4	231	219.5	0.95	1.0	1978/79-2008/09	$0.25yr^{-1}$
2009/10	4	234	245.7	1.05	0.6	1978/79-2009/10	$0.25yr^{-1}$

(c) Stocks in Tier 5

Year	Tier	Year to define Average catchB_{MSY}	Natural Mortality
2008/09	5	1978/79-2008/09	$0.25yr^{-1}$
2009/10	5	1978/79-2009/10	$0.25yr^{-1}$